2.5 Linear and Non-Linear Relations

Strand:
Linear Relations

Student Text Pages
77 to 87

Suggested Timing
80–160 min (160 min if more experiments are done)

Tools
- grid paper

Technology Tools
- graphing calculators
- *Fathom*™
- Corel® *Quattro Pro*®
- Microsoft® *Excel*
- computers

Related Resources
BLM G10 Grid Paper
BLM T6 *Fathom*™
BLM T1 Corel® *Quattro Pro*® 8
BLM T2 Corel® *Quattro Pro*® 10
BLM T3 Microsoft® *Excel*
BLM 2.5.1 Practice: Linear and Non-Linear Relations
BLM A5 Problem Solving Checklist
BLM 2.5.2 Achievement Check Rubric
BLM 2.5.3 Student Success: Crossword

Mathematical Process Expectations Emphasis

- [x] Problem Solving
- [ ] Reasoning and Proving
- [x] Reflecting
- [x] Selecting Tools and Computational Strategies
- [ ] Connecting
- [x] Representing
- [x] Communicating

Specific Expectations

Using Data Management to Investigate Relationships

RE1.01 interpret the meanings of points on scatter plots or graphs that represent linear relations, including scatter plots or graphs in more than one quadrant (e.g., on a scatter plot of height versus age, interpret the point (13, 150) as representing a student who is 13 years old and 150 cm tall; identify points on the graph that represent students who are taller and younger than this student);

RE1.02 pose problems, identify variables, and formulate hypotheses associated with relationships between two variables;

RE1.04 describe trends and relationships observed in data, make inferences from data, compare the inferences with hypotheses about the data, and explain any differences between the inferences and the hypotheses (e.g., describe the trend observed in the data. Does a relationship seem to exist? Of what sort? Is the outcome consistent with your hypothesis? Identify and explain any outlying pieces of data. Suggest a formula that relates the variables. How might you vary this experiment to examine other relationships?);

Understanding Characteristics of Linear Relations

RE2.01 construct tables of values, graphs, and equations, using a variety of tools (e.g., graphing calculators, spreadsheets, graphing software, paper and pencil), to represent linear relations derived from descriptions of realistic situations;

RE2.02 construct tables of values, scatter plots, and lines or curves of best fit as appropriate, using a variety of tools (e.g., spreadsheets, graphing software, graphing calculators, paper and pencil), for linearly related and non-linearly related data collected from a variety of sources (e.g., experiments, electronic secondary sources, patterning with concrete materials);

RE2.03 identify, through investigation, some properties of linear relations (i.e., numerically, the first difference is a constant, which represents a constant rate of change; graphically, a straight line represents the relation), and apply these properties to determine whether a relation is linear or non-linear;

RE2.05 determine the equation of a line of best fit for a scatter plot, using an informal process (e.g., using a movable line in dynamic statistical software; using a process of trial and error on a graphing calculator; determining the equation of the line joining two carefully chosen points on the scatter plot).

Connecting Various Representations of Linear Relations

RE3.03 determine other representations of a linear relation, given one representation (e.g., given a numeric model, determine a graphical model and an algebraic model; given a graph, determine some points on the graph and determine an algebraic model).

Common Errors

- Some students may draw the line of best fit so that it goes through the greatest number of points possible.

R_x Give students an example where six points line up in a perfectly straight line, and an additional three points lie scattered above that line. Show that the line going through those six points cannot be the line of best fit because there is not a balance between points above and below the line.

Ongoing Assessment

Use Achievement Check question 10 to monitor student success. See the Achievement Check Answers and **BLM 2.5.2 Achievement Check Rubric** to assist you in assessing your students.

Communicate Your Understanding questions can be used as quizzes to assess student Communication skills (see **BLM 2.5.2 Achievement Check Rubric**).

Teaching Suggestions

- Introduce the Investigate by reading the opening paragraph as a class. Have the students answer the questions individually before having a class discussion to summarize the concept of a linear relation. This will flow into the concept of a line of best fit that can be drawn for a data relationship that appears linear, or a curve of best fit for a data relationship that appears non-linear. (15 min)
- As a class, work through Example 1, or an example of a scatter plot that provides a linear relationship. Although there are formal methods of finding the line or curve of best fit, for now, finding the line or curve that comes closest to as many points as possible is best. You may wish to use **BLM G10 Grid Paper**, **BLM T6 *Fathom*™**, **BLM T1 Corel® *Quattro Pro*® 8**, **BLM T2 Corel® *Quattro Pro*® 10**, and/or **BLM T3 Microsoft® *Excel*** for this section. (15 min)
- Example 2 explains when it is not appropriate to find a line of best fit. This is an initial stage of critical analysis and should be stressed. (5 min)
- Review the vocabulary, **linear relation**, **line of best fit**, and **curve of best fit**, before assigning the activities. (2 min)
- Assign activities C1, C2, and Practise questions 1–4. (20 min)
- You may wish to use **BLM 2.5.1 Practice: Linear and Non-Linear Relations** for remediation or extra practice.

Investigate Answers (page 77)

1. Answers will vary. Both boys and girls grow the fastest within the first 3 months, and then, their growth rate slows down a little.

2. Answers will vary. Young girls grow a little bit slower and are a few centimetres shorter than boys.

3. Although neither growth rate is linear, they both start to get very close to being linear after 18 months.

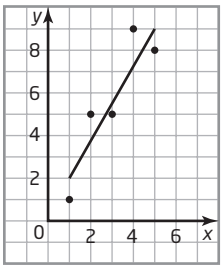
4. From 0 to 18 months, the growth rate of boys and girls appears to be non-linear.

5. Changes in linear graphs are constant while those in non-linear graphs occur a lot faster or slower.

Communicate Your Understanding Responses (page 83)

C1. A. The points lie close to a straight line.

C2. Yes. The points can be scattered evenly above and below the line of best fit. Graphs will vary. Example:



Accommodations

Visual—Give students opportunities to work together with a reading buddy who will read the technology instructions read to them.

Spatial—Encourage students to colour code the *x*- and *y*-axes on a graph when plotting points, linear relations, and non-linear relations.

Language—Let students work with a student note taker or reading buddy who will take notes and read the questions in the exercises for them.

Student Success

Have students collect examples of surveys from newspapers and other print sources. Instruct students to create a collage of the results, highlighting the information and critiquing how the information is presented. Once students have completed Section 2.5, have them complete the crossword puzzle of data management terminology on **BLM 2.5.3 Student Success: Crossword**.

Practise

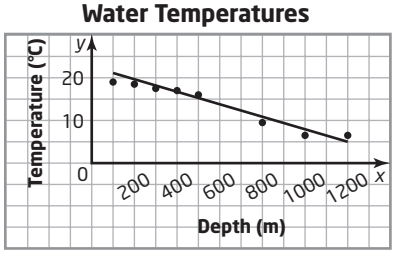
Students should have few difficulties with these questions. Make sure they use appropriate scales when graphing the scatter plots.

Connect and Apply

Question 6d) invites students to consider other factors that affect both the independent and dependent variables. Question 7 is an excellent example of the dangers of extrapolation under changing conditions. You may wish to use **BLM A5 Problem Solving Checklist** to assist you in assessing your students. It is important that students carry out a few experiments in this unit. You may wish to assign question 8 to half the class and question 9 to the other half, if you are pressed for time. Question 10 is an excellent formative assessment tool. You may wish to use **BLM 2.5.2 Achievement Check Rubric** to assist you in assessing your students. You may wish to use **BLM G10 Grid Paper** to help with questions 4 to 12.

Achievement Check Answers (page 86)

10. a) and b)



c) As the depth increases, the temperature decreases.

d) At a depth of 700 m, the water temperature would be 12°C.

e) At a depth of 1600 m, the water temperature would be −0.7°C.

f) Interpolating is more accurate than extrapolating because the answer can be checked by the data points around it, therefore, the estimate for d) is likely to be more accurate.

Extend

Students who are able to develop the concept of first differences on their own will be successful with question 11. Although question 12 should be a relatively straightforward question, the presence of fractions makes it more challenging. It should be accessible to most level 3 or 4 students.

Exercise Guide

Category	Question Number
Minimum (essential questions for all students to cover the expectations)	1–5, 8
Typical	1–7 and 8 or 9
Extension	11–14